Effects of Different Levels of Selenium Supplements on Growth Performance and Immune Response of Broiler Chicken in Hot Humid Climatic Condition

A Thesis

By

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SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2020

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REGISTRATION NO. 13-05496

A Thesis

Submitted to Department of Animal Nutrition, Genetics and Breeding,

Sher-e-Bangla Agricultural University, Dhaka-1207

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS) IN ANIMAL NUTRITION

SEMESTER: JANUARY-JUNE, 2020

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অধ্যাপক ড. মোঃ মোফাজ্জল হোসাইন
ডীন (জানুয়ারি ২০১৫ থেকে জানুয়ারি ২০১৭)
এনিম্যাল সাইন্স এন্ড ভেটেরিনারি মেডিসিন অনুষদ
সাবেক বিভাগীয় চেয়ারম্যান
এনিম্যাল নিউট্রিশন, জেনেটিক্স এন্ড ব্রিডিং বিভাগ
প্রাক্তন প্রক্টর
শেরেবাংলা কৃষি বিশ্ববিদ্যালয়, ঢাকা-১২০৭

CERTIFICATE

This is to certify that the thesis entitled, "Effects of Different Levels of Selenium Supplements on Growth Performance and Immune Response of Broiler Chicken in Hot Humid Climatic Condition" Submitted to the Department of Animal Nutrition, Genetics and Breeding, Faculty of Animal science and veterinary medicine, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in Animal Nutrition embodies the result of a piece of bonafide research work carried out by Md. Harun-Or-Rashid, Registration No. 13-05496 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by him.

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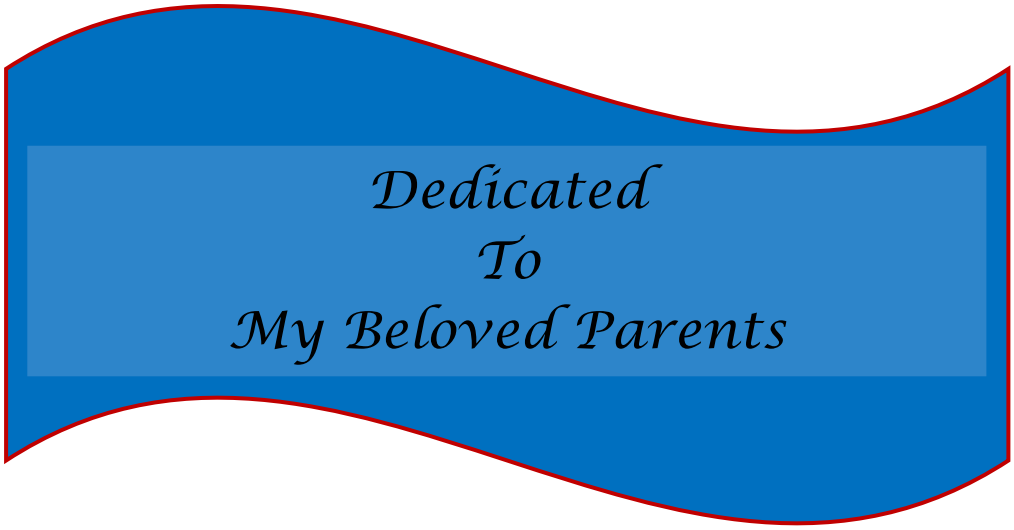
Dedicated
To
My Beloved Parents

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah Who enable me to complete this thesis. I would like to express my heartfelt respect, deepest sense of gratitude, profound appreciation and ever indebtedness to my Supervisor Md. Mufazzal Hossain, Professor, Department of Animal nutrition, Genetics and Breeding, Sher-E-Bangla Agricultural University, (SAU), Dhaka for his sincere guidance, scholastic supervision, constructive criticism, and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

The author expresses his sincere appreciation, profound sense, respect and immense indebtedness to respected Co-supervisor Dr. Mofassara Akter, Associate Professor, department of Animal nutrition, Genetics and Breeding, Sher-E-Bangla Agricultural University, (SAU) for extending generous help, scholastic guidance, constructive criticism, continuous inspiration during the research work and preparation of the manuscript of the thesis.

The author would like to express his heart felt indebtedness and profound appreciation to my respectable all of the teachers, Department of Animal nutrition, Genetics and Breeding, Sher-E-Bangla Agricultural University, Dhaka for his/her nice co-operation sincere guidance, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

The author acknowledges Sher-e-Bangla Agricultural University Research System (SAURES) for providing financial aid that enable him to complete the research work more smoothly.

The author would like to express cordial thanks to his friends Mohammad Alauddin Ala, Md. Shafiqur Rahman, Md. Imran Hossain for their heartiest assistance in her research period.

The author would like to express his last but not least profound gratitude to his beloved father, mother, brothers and sisters who sacrificed all their happiness during the whole study period in his life as well as during this MS study. He is grateful to all of his relatives for their inspiration, blessing and encouragement that opened the gate of higher studies in his life.

Finally, the author appreciated the assistance rendered by the staff of the Department of Animal nutrition, Genetics and Breeding specially Md. Kholilur Rahman who have helped him during the period of study.

The Author

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LIST OF ACRONYMS AND ABBREVIATION

ABBREVIATION		FULL MEANING
A.M	=	Anti meridiem
ADG	=	Average daily gain
ANOVA	=	Analysis of variance
Avg.	=	Average
BWG	=	Body weight gain
CP	=	Crude Protein
DOC	=	Day old chick
DP	=	Dressing Percentage
DSM	=	Diagnostic and statistical manual
e.g.	=	For example
et al.	=	And others/associates
EU	=	European Union
FAO	=	Food and agricultural organization
FC	=	Feed consumption
FCR	=	Feed conversion ratio
FI	=	Feed intake
g	=	Gram
i.e.	=	That is
K Cal	=	Kilo calorie
Kg	=	Kilogram
L	=	Litre
M.S.	=	Master of science
ME	=	Metabolizable energy
ml	=	Mililitre
mm	=	Milimetre
No.	=	Number

LIST OF ACRONYMS AND ABBREVIATION (CONT'D)

ABBREVIATION		FULL MEANING
NS	=	Non-significance
RH	=	Relative Humidity
SAU	=	Sher-e-Bangla Agricultural University
SE	=	Statistical Error
Se	=	Selenium
SPSS	=	Statistical Package for Social Sciences
Viz.	=	Such as
Vs.	=	Versus
WHO	=	World Health Organization
Wks.	=	Weeks

LIST OF SYMBOLS

SYMBOLS		FULL MEANING
*	=	5% level of significance
&	=	And
@	=	At the rate of
℃	=	Degree celcius
$	=	Dollar
>	=	Greater than
<	=	Less than
/	=	Per
%	=	Percentage
±	=	Plus-minus
:	=	Ratio

EFFECTS OF DIFFERENT LEVELS OF SELENIUM SUPPLEMENTS ON GROWTH PERFORMANCE AND IMMUNE RESPONSE OF BROILER CHICKEN IN HOT HUMID CLIMATIC CONDITION

ABSTRACT

A total of 120 day-old Cobb 500 broiler chicks were reared in Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. The present study was designed to evaluate the growth performance and immune response of commercial broiler chicks fed diet containing Selenium Powder in hot humid climatic condition. Chicks were divided randomly into 4 experimental groups of 3 replicates (10 chicks with each replications). One of the 4 experimental group was fed diet as control while, the remaining three groups were fed diet with 3 levels of Se (0.1g Se/kg feed, 0.3g Se/kg feed and 0.5g Se/kg feed). The results showed that average live weight and live weight gain was significant ($P<0.05$) in comparison to others. Though best live weight and live weight gain was found at 0.5g/kg Se concentration but it was very close with control group. The feed consumption and FCR were not influence significantly by the dietary inclusion of Se as compared to control group. The highest FCR was in 0.1g Se/Kg feed and lowest was in control. However, a linear increase in feed consumption has found with the increase in Se concentration in the diet. Birds fed 0.5g Se/kg feed diets achieved superior feed consumption compared to those of the control group. The relative weight of carcass parts, giblet organ and dressing percent of different groups showed that there was significant ($P<0.05$) difference between the groups. The superior dressing percentage and carcass parts were found in 0.3g Se/kg feed concentration. In addition, the present study showed that feeding dietary Se had no significant ($P>0.05$) effects on survivability and uniformity among the treatments though there was no mortality in treatments group. The results of hematological studies as well as immune response showed no significant ($P>0.05$) differences due to supplementation of Se. Analyzing the above findings it can be concluded that Selenium don't hamper growth performance and immunity of broiler therefore it can be use with feed for human health benefit. Because the residual Selenium has a positive impact on human health as Selenium is an essential micronutrient for human.

CHAPTER 1

INTRODUCTION

1.1 General background

Bangladesh is an agro-based country where 80% of the population depends on agriculture. Poultry plays a vital role in the income generating framework of the rural people of Bangladesh. The contribution of poultry sector towards promoting resources for improving the life style and livelihood of landless and marginal farmers is noted worthy. In large-scale rearing facilities where poultry are exposed to stressful conditions may lead to diseases or decrease the production potentials which in turn results in serious economic losses. Poultry such as chicken is one the main sources of animal protein for Bangladeshi people (Kamal and Shafiullah, 2016).

Due to increasing population, there is an increasing demand for meat and eggs which led to commercialization of poultry production, with a large number of farms now operating across the country (Raha, 2007). One of the major challenges this industry faces is the spreading of diseases among the poultry population due to bacterial pathogens which results in serious economic losses (Huque *et al.*, 2011). As a result, the use of antimicrobial agents and growth promoters is substantially increasing in the poultry industry to prevent diseases and to promote faster growth (Islam *et al.*, 2016). An assortment of substances, such as growth promoters is added to the feed and the drinking water of poultry to improve its production and reduce or prevent the spread of diseases (Diarra and Malouin, 2014). These are substances used to increase the feed efficiency, average daily gain, eggs and meat production.

So, modern scientist are working on using various natural feed ingredients and minerals for developing growth and immunity in broiler chicken. Selenium is one of them. Selenium is an essential trace element which occurs in cereals and primarily in the form of selenomethionine. Selenium (Se) is an essential mineral for a range of organisms including birds (Schwarz and Foltz, 1957). It can be found as a part of at least 25 selenoproteins in living bodies (Brown and Arthur, 2001). Therefore, it is unsurprising that selenoproteins are considered to be involved in the regulation of a variety of physiological functions including reproduction, immunity, growth and development (Surai, 2002).

1.2 State of the problem

The essential trace mineral, selenium, is of fundamental importance to human health (Rayman, 2000, 2004). Selenium is known to have important roles in reproductive functions and development, immune competence and ageing. As a constituent of selenoproteins, selenium has structural and enzymic roles, in the latter context being best-known as an antioxidant and catalyst for the production of an active thyroid hormone. Selenium is a component of the cell enzyme glutathione peroxidase (Mills, 1957). The Se content of animal feed ingredients is dependent on the Se concentration in soil. The Se reserve in soils was depleted in the Czech Republic (Pavlata *et al*., 2000). Se intake is lower than the recommended daily allowance: 55–70 µg (Velisek, 2002). Therefore there is a need to increase Se consumption in the general population and selenium should be supplemented in the form in which it naturally occurs in foods. The amount of Se available for assimilation by the tissues is dependent on the form and concentration of the element while organic selenium is deposited in the breast muscle more efficiently than inorganic selenium (Choct *et al*., 2004). Inorganic and organic forms of Se (selenite, selenate, selenide, selenomethionine, selenium enriched yeast, selenium enriched alga) may be used as supplements. Moreover residual selenium that come from broiler chicken is beneficial for human health also. Low selenium status has been associated with increased risk of mortality, poor immune function, and cognitive decline. Higher selenium status or selenium supplementation has antiviral effects, is essential for successful male and female reproduction, and reduces the risk of autoimmune thyroid disease (Margaret *et al*., 2012).

1.3 Justification of the study

A successful poultry production requires the inputs of proper genetic makeup, nutritional and health care management. In intensive poultry husbandry practice diseases have been a potential threat to the economics of the poultry industry and caused severe losses. The chicks from day old stage are exposed to variety of stresses such as intensive production methods, high density as well as other nutritional and pharmacological factors. These stresses adversely affect the immune status of the birds. Nutrition plays a significant role in the development and function of the immune system (Khan *et al.*, 1993). In modern poultry production, the broilers are selectively bred to reach the market weight early. As a consequence of faster growth rate, birds are under physiological and immunological stress that makes them more sensitive to infectious

diseases (Gregar, 2006). Poultry meat is very sensitive to oxidative deterioration due to a high content of polyunsaturated fatty acids (Nanari *et al.,* 2004). Lipid oxidation is an important determinant of shelf life of meat and meat products. Post-slaughter biochemical changes involved in the conversion of muscle to meat are accompanied by a loss of cellular antioxidant defences and an increased propensity of meat lipids to undergo oxidation (Morrisey *et al.,* 1994). This contributes to undesirable changes in a number of quality parameters, including loss of water-holding capacity, texture and flavour. Microbial growth leads to the precipitation of public health hazards which, in turn, contribute to the deterioration in meat products during storage (Fernández-López *et al.,* 2005). Due to the above reasons, consumers are more interested in the beneficial health promoting effects of functional foods enriched with natural ingredients. This has led to the opportunities for marketing meat products with added nutritional value and quality (Grashorn, 2007). Therefore, application of suitable agents having both antioxidants and antimicrobial activities may be useful for maintaining meat quality and extending shelf-life. Numerous studies have demonstrated that lipid oxidation and microbial growth in chicken meat and its products can be controlled or minimized by using α-tocopherol and Se (Nanari *et al*., 2004; Grashorn, 2007). Selenium has been recognized as an essential dietary nutrient that plays important roles in immune function, health, and productivity.

1.4 Objectives

With this background, the work was planned to explore the possibilities of Selenium in broiler chicken feeds with the following specific objectives:

- To find out effect of selenium in production performance of broiler chicken
- To identify efficacy of selenium in carcass and dressing yield of broiler chicken in hot humid climatic condition
- To determine the immune response of Se in broiler.

CHAPTER 2

REVIEW OF LITERATURE

Achieving maximum health and performance of poultry requires nutritionally balanced diets. One of the common issues is inadequate feeding programs that can lead to vitamin and mineral deficiencies for the birds. Vitamins and minerals are very important components of a chicken's diet and unless a formulated ration is feed, it is likely that deficiencies will occur. During the last decades, the diets for broilers have been routinely supplemented with trace elements in the form of inorganic salts to avoid mineral deficiency. Trace elements function as parts of proteins, hormones, enzymes or as cofactors that activate specific enzymes. These trace elements affect both growth performance and immune status of broilers. It is well known that deficiency of trace elements decreases the antibody production, T cell proliferation response to mitogens, neutrophil function and the natural killer cell activity (Chandra and McBean, 1994). In addition, the trace elements are involved in the metabolic activities via metalloenzymes which are essential for the antioxidant protection of cells.

2.1 Selenium

Selenium (Se) is a dietary essential trace mineral for poultry (NRC, 1994). It was discovered in 1817 by Berzelius (Levander, 1986; Sunde, 1997), and for many years, Se was thought to be toxic to animals. However, in 1957, Se was reported to prevent liver necrosis in rats (Schwarz and Foltz, 1957), which established Se as a dietary essential nutrient. Since then, Se has been identified to be an integral part of over 30 distinct selenoproteins, including the enzyme, glutathione peroxidise (Sunde, 1997; Arthur, 2000). First discovered selenoprotein was enzyme glutathione peroxidase (GSH-Px) which contains this micro element in its active place (Rotruck *et al*., 1973). The glutathione peroxidases are a group of antioxidant enzymes that are essential for protection of the cells of the body from per oxidative and free-radical damage (Sunde, 1997; Arthur, 2000). GSH-Px concentration and activity is directly related to the selenium status of the animal (Brigelius-Flohe, 1999). Selenium came to medical notice later because of its toxicity to human beings working in industries. Selenium was also recognized as an important veterinary toxin, which is seen in animals that have eaten high-selenium plants. In 1954, the first hints of specific biological functions of selenium were discovered in microorganisms (Pinsent, 1954; Stadtman, 2002). However, in 1957, Schwarz and Foltz identified selenium to be one of three compounds that

prevented liver necrosis (vitamin-E and cysteine were the others), thus establishing selenium as a nutritionally essential trace mineral. In the 1970s, it was shown to be present in two independent sets of enzymes. This was followed by the discovery of selenocysteine in proteins. During the 1980s, it was shown that selenocysteine is encoded by the codon UGA. The recoding mechanism was worked out first in bacteria and then in mammals. Despite the establishment of a dietary need for Se, it still is considered to be the most toxic dietary essential trace mineral. Therefore, the FDA regulates supplementation of Se into poultry diets (FDA, 2004).

Selenium salts are toxic in large amounts, but trace amounts are necessary for cellular function in many organisms, including all animals. Selenium is a component of the antioxidant enzymes glutathione peroxidase and thioredoxin reductase (which indirectly reduce certain oxidized molecules in animals). It is also found in three deiodinase enzymes, which convert one thyroid hormone to another. It is also involved in the regulation of energy metabolism, spermatozoa function and immunity. It is recognized as having anticarcinogenic and antiviral properties that are essential in the face of stress. All of these factors emphasize the necessity of this trace mineral in the diets of all humans and animals. The lack of trace elements can impact significantly the health and wellbeing of animals.

In poultry production selenium is added to food mainly for the purpose of prevention of certain diseases by its positive effect on immunological system and increases its production characteristics, primarily body mass and more efficient utilization of food (Combs, 1977; Jokić *et al*., 2005). There are numerous papers in literature presenting the investigation of the effect of different selenium sources and levels on quality of broiler meat (Edens, 1997, 2001; Surai and Dvorska, 2002 and Džinić *et al*., 2006). Adding Se to poultry diets can provide the poultry industry with a simple method for improving lipid oxidation of poultry meat (Ryu *et al*., 2005). Although the requirement for Se often is met by the natural feedstuffs in poultry diets, there are several detrimental conditions that can result in poultry when dietary Se is deficient. Exudative diathesis, pancreatic fibrosis, and impaired reproduction are observed if the Se level in the diet is deficient. The Se requirement for the laying hen ranges from 0.05 to 0.08 ppm depending on daily feed intake while the broiler's requirement is 0.15 ppm. The maximum level of Se supplementation allowed in poultry diets is 0.30 ppm (NRC, 1994).

2.2 Metabolism of Selenium

The metabolism of Se is dependent on its chemical form and on the amount ingested. Wright and Bell (1966), using sheep and pigs, agree that the majority of dietary Se is absorbed in the duodenum.

Inorganic Se sources are metabolized first from selenate to selenite. Then, selenite is nonenzymically reduced to elemental Se by glutathione forming selenodiglutathione (GS-Se-SG) (Ganther, 1966). In the absence of oxygen, selenodiglutathione is further reduced to selenide (HSe-) by glutathione reductase (Hsieh and Ganther, 1975). At this stage, selenide can have several fates. It can be methylated to form methaneselenol (CH3SeH), which then form dimethylselenide or trimethylselenonium ion ((CH3) xSeH) (Hsieh and Ganther, 1977). Selenide also can bind to the Se-binding proteins, or be a substrate for selenophosphate synthetase for the tRNA-mediated synthesis of selenoproteins. This last step converts inorganic Se into the organic forms of Se that are found in mammalian tissues.

Organic Se is metabolized differently than inorganic Se. Dietary selenomethionine can be readily incorporated into protein ([Se] Met) as selenomethionine because it is esterifies to methioninyl-tRNA only slightly less efficiently as Methionine (Hoffman *et al*., 1970). Selenomethionine can be metabolized to Se-adenosyl methionine (SeAM), and then to Se-adenosyl homocysteine which is readily converted to selenocysteine via cystathionine β-synthase and cystathionine γ-lyase. Selenocysteine then can be incorporated into proteins or degraded, releasing selenite, or it can be degraded by selenocysteine lyase, releasing elemental Se, which can be reduced to selenide (Esaki *et al*., 1982). Another fate for selenomethionine is to be transaminated to methaneselenol, and then methaneselenol can be transformed to selenide via Smethyltransferase (Sunde, 1997). At this stage, selenide would be metabolized as mentioned in case of inorganic Se. Metabolism of Se presented in Figure1.

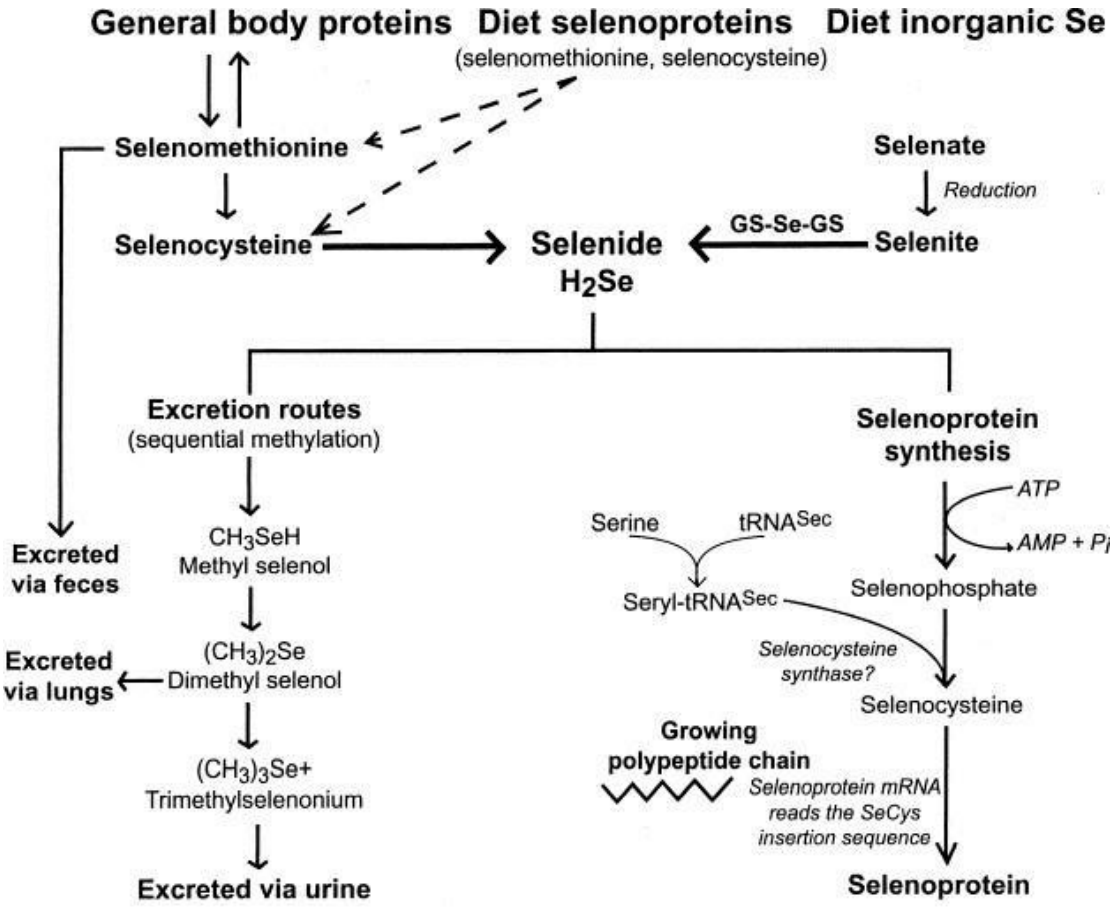

Fig1: Metabolism of Selenium

2.3 Symptoms of Se deficiency

In man, an association between low selenium status and Keshan disease, a cardiomyopathy endemic to part of China, was documented in 1979 (Keshan Disease Research Group, 1979). Brown *et al*. (1986), described an association between muscle weakness and severe selenium deficiency in a female patient with sort-bowel syndrome who was maintained on parental nutrition at home. Syndromes included inability to rise from a squatting position, rapid tiring when climbing stairs, and difficulty lifting heavy objects. Other selenium deficient disease is Kashin-Beck disease. The disease has observed in regions with soil low in selenium. Symptoms of the disease include joint swelling, pain, general malaise, short status (due to the effect of the disease on the growth plate of tubular bone), and secondary osteoarthritis (Sokoloff, 1988). The sign of selenium deficiency have also been reported in quail and chicken (Jensen, 1968; Thompson and Scott, 1969). It includes loss of body weight, poor feathering, impaired reproduction, reduced hatchability, and reduced viability. In ducklings, selenium deficiency reduced plasma glutathione peroxidase activity and body weight gain,

increased mortality. Ducklings that succumb to selenium deficiency may exhibit necrosis of several tissues including the ventriculus, heart, skeletal muscle and smooth muscle of intestine, and show signs of hydropericardium and ascites (Dean and Combs, 1981). Chicks severely deficient in selenium exhibit poor growth and feathering, impaired fat digestion, pancreatic atrophy and fibrosis, and reduced activities of selenium dependent glutathione peroxidase in pancreas. Selenium deficiency depressed growth of broilers by inhibiting hepatic 5'-deiodinase activity, which causes lower plasma 3,5,3-triiodothyronine concentration (Klasing and Austic, 2003).

2.4 Toxicity of Se

In livestock, interest in the toxic effect of selenium was obtained after the discovery in the early 1930's by scientists from the U.S. Department of Agriculture and from South Dakota and Wyoming State Agricultural Experiment Stations that selenium was the toxic substance in forages and grains responsible for "blind staggers" and "alkali disease" which sometimes occurred in livestock in the certain areas of the American western plains (NRC, 1971). Chronic selenium toxicity in livestock occurs when animals consume seleniferous plants containing 3-20 ppm of selenium over a prolonged period. When it occurs in cattle and horses, it is often called alkali disease. Symptoms include lameness, loss of vitality, hoof malformations, loss of hair in the mane and tail, atrophy cirrhosis of the liver and chronic nephritis (NRC, 1983). Laboratory rats poisoned with selenium on long term basis exhibit growth depression and cirrhosis (Shike, 2005). Selenium toxicity had been reported to be a cause of death and deformities of embryos and chicks in aquatic birds within Kesterson area of California. Selenosis was caused by high concentration of selenium in the runoff which had bioaccumulated in the bird's food chain by plants, invertebrates and fish (Ohlendorf *et al*., 1988). Selenium in a diet of the mallard at 10 ppm as selenomethionine or 25 ppm as sodium selenite caused a 40-44 % decreased in the total number of eggs that hatched compared with control (Hoffman and Heinz, 1988).

2.5 Effect of Selenium on growth performance

In poults at the age of 28 days Cantor *et al*. (1982) recorded higher live weight and increased feed intake after dietary Se supplementation in the form of sodium selenite or selenomethionine (0.04 to 0.12 ppm Se).

Todorovic *et al*. (1999) supplemented sodium selenite at the amounts of 2, 5, 10, 20 and 30 mg/Se to a diet for broiler chickens. The supplementation of 2 mg/kg Se did not influence the live weight of chickens, 5 mg/kg Se decreased daily weight gain and the amounts of 15, 20 and 30 mg/kg Se resulted in up to 80% mortality of broiler chickens.

He-Jianhua *et al*. (2000) conducted three experiments in order to determine the effects of dietary Se on growth, skeletal muscle protein turnover and thyroid hormone status in broiler chickens. Broiler chickens were raised on a Se-deficient diet until 12 d of age and then used for the experiments. In Experiment 1, twenty-eight birds were randomly assigned to four groups and fed purified diets with the following amounts of Se supplementation: 0·0, 0·1, 0·3 and 0·5 mg Se/kg diet. Dietary Se supplementation significantly increased plasma 3, 5, 3′-triiodothyronine (T_3) concentration and improved growth, while plasma thyroxine (T_4) concentration was decreased. In Experiment 2, twenty-eight birds were assigned to four groups and fed either a Se-deficient diet or a Sesupplemented diet (0·3 mg Se/kg diet) with or without the supplementation of iopanoic acid, a specific inhibitor of 5′-deiodinase (5 mg/kg diet). The growth was promoted and feed efficiency was improved by dietary Se supplementation as was also observed in Experiment 1. However, this effect of Se was halted by iopanoic acid supplementation. Hepatic 5′-deiodinase activity was elevated by Se and inhibited by iopanoic acid. In Experiment 3, birds were fed on the following diets to show that Se influences growth of birds via thyroid hormone metabolism: Se deficient diet, Se-supplemented diets (0·1 and 0·3 mg/kg) and T_3 supplemented diets (0·1 and 0·3 mg/kg diet). Lower dietary T_3 supplementation (0·1 mg/kg diet) resulted in growth promotion similar to Se supplementation, while higher level of T_3 caused growth depression. In conclusion, it was shown in the present study that Se deficiency depresses growth of broilers by inhibiting hepatic 5′-deiodinase activity which causes lower plasma T_3 concentration.

In Japanese quail kept under a heat stress Sahin and Kucuk (2001) also reported higher performance and dressing percentage after the application of a dietary supplement of 250 mg vitamin-E and 0.2 mg Se in the form of Na_2SeO_3.

Edens *et al*. (2001), and Spears *et al*. (2003) reported no difference in gain or feed intake of broilers fed various concentrations (0 to 0.5 ppm) of Se from SS or SM, whereas Edens *et al*. (2001) reported no differences in BW or feed efficiency when broilers were fed diets containing 0.20 ppm Se from SS or SY.

Deniz *et al*. and Payne and Southern (2005) reported that the growth of broilers was not affected by the source or level of Se supplemented in the diets. Supplemental Se decreased ($p = 0.03$) feed intake and increased ($p = 0.04$) feed efficiency during the first 3 wk, but not during the following 3 wk. Deniz *et al*. (2005) reported an improved feed conversion ratio when broilers were supplemented with organic Se, in comparison with a control or with broilers receiving inorganic Se. In contrast, Payne and Southern (2005) observed no differences in feed efficiency attributable to the supplemental Se source.

Zelenka and Fajmonova (2005) examined slow-growing laying-type chickens (SG) and in fast-growing broiler hybrids (FG) fed *ad libitum* on a diet with 265 μg of selenium/kg, including 128 μg of selenium added as sodium selenite. Coefficients of selenium retention and retention per unit of body gain were higher in SG chickens. The influence of age on selenium content in BW gain of birds was evident ($p < 0.01$). From 5 to 40 d, allometric coefficients were 1.444 and 1.070 for SG and FG, respectively, and from d 40 to 100 the corresponding values were 1.282 and 1.081, respectively.

Yoon *et al*. (2007) conducted an experiment using 360 one-day-old Jumbo Cornish Cross broiler chicks to evaluate the effects of the source and concentration of Se on growth performance and Se retention. Broilers were fed corn-soy-based diets formulated to contain 0 (negative control), 0.1, 0.2, or 0.3 ppm of supplemental Se from Seleno source AF (Se yeast A, Diamond V Mills, Cedar Rapids, IA), 0.3 ppm of Se from Sel-Plex (Se yeast B, Alltech, Nicholasville, KY), or 0.3 ppm of Se from sodium selenite. Starter diets were fed for the first 21 d (6 replicates of 10 broilers per treatment). On d 21, broilers were regrouped within dietary treatments to finisher cages (11 replicates of 5 broilers per treatment) and fed finisher diets for the following 21 d. Result of the study suggests that selenium supplementation did not influence ($p > 0.05$) the growth performance of broilers at 42 d of age.

Hosseini (2011) conducted an experiment to assess the effects of replacing sodium selenite (SS) by Se-yeast (SY) in diet on growth performance and selenium and vit E contents in male broilers tissue. One day-old 240 male birds were randomly assigned to 4 treatments with 4 replicates of 15 birds each.

The experimental grower diets that were supplemented with SS or SY at 0.3 mg Se/kg of feed, as follows: T_1= 0.3 SS, T_2= 0.2 SS+0.1 SY, T3= 0.1 SS+0.2 SY, and T_4= 0.3 SY were given *ad libitum* to the birds during a 21 d-old grower period. The basal diet was also, supplemented with 75 mg of vitamin-E. SY enrichment of grower diets increased the weight of live chickens significantly ($P<0.01$). Also, birds fed 3% SY (T_4) diet had better ($P<0.05$) feed conversion ratio (FCR) compared to the others treatments.

Wang and Zhou (2011) conducted an experiment to investigate the effect of feed supplementation with nano elemental Se (Nano-Se) on growth performance, tissue Se distribution, meat quality, and glutathione peroxidase (GSH-Px) activity in Guangxi Yellow chicken. Four treatments (control, T_1, T_2, and T_3 treatment groups) with 3 replicates of 30 chickens each were carried out.

Diets for the control, T_1, T_2, and T_3 groups consisted of the basal diet supplemented with, respectively, 0.00, 0.10, 0.30, and 0.50 mg/kg of Nano-Se. Improved final BW, daily BW gain (DWG), feed conversion ratio, and survival rate ($P< 0.05$) were observed in the groups supplemented with Nano-Se as compared with the control groups after 90 d of feeding. It could be concluded from this study that supplementing diets with 0.30 mg/kg of Nano-Se for was effective in increasing the growth performance and feed conversion ratio of chickens.

2.6 Effect of selenium on carcass characteristics and meat quality

Echevarria *et al*. (1988) stated that the Se concentration in tissues, particularly in kidneys and liver, increased linearly with the increasing Se content in the diet. Muscle Se increased ($P\leq 0.01$) from an average of 0.42 in control birds to 1.07 mg/kg for birds fed 9 mg/kg Se.

Mahan *et al*. (1999) showed that 120 hours after slaughter water losses in meat of fatteners that received sodium selenite were higher than in animals which selenium were not given or selenium enriched yeast was applied in feed. It could be a result of meat's prooxidants decaying by inorganic form of selenium.

Downs *et al*. (2000) reported the average dressing percentage of 71% after an addition of 0.3 mg/kg Se in the form of selenite and Se-enriched yeast while the carcass and deboned parts yield was not influenced.

Naylor *et al*. (2000) noted clearly in chickens that received selenium in organic form (selenium enriched yeast) ($P \leq 0.01$) lower meat's water losses in comparison with meat of broilers receiving that microelements as a sodium selenite.

Choct *et al*. (2004) noted selenium is required by poultry for the maintenance of optimal health and meat quality. Selenium supplementation increased feathering, with organic selenium (selenised yeast) being superior to inorganic selenium (sodium selenite). Birds receiving organic selenium in their diets had improved eviscerated weight, breast yield and reduced drip loss. There were significant concentration x source interactions on yields of breasts and marylands (thigh plus drumstick), with elevated levels of organic selenium increasing the yields, whereas the opposite was true for the inorganic selenium. Higher carcass and breast meat yield in broilers' carcass that received selenium enriched yeast in feed.

Payne and Southern (2005) in experiment carried out on broilers receiving sodium selenite and selenium enriched yeast stated that carcass yield and breast meat yield in carcass did not depend on chemical form of this microelement in feed.

Sevcikova *et al*. (2006) conducted an experiment to see the effect of dietary supplementation of selenium in an organic form on performance, carcass traits and selenium content in tissues of broiler cockerels Ross 308 was studied. The soya-wheat-maize diet contained 50 mg vitamin-E/kg. The experiment was conducted on 810 straight-run broiler cockerels randomly divided into 3 groups: Group: I – control, without selenium supplement; experimental, group: II – 0.3 mg Se/kg, Se-enriched yeast was applied as a Se source; group: III – 0.3 mg Se/kg. Se enriched alga Chlorella as a Se source. The broiler chickens were slaughtered at 42 days of age. In performance traits higher ($p \leq 0.05$) live weight of broiler chickens was recorded in the experimental groups (II – 2 430.6 g and III – 2 425.2 g). No significant differences between the groups were found out in carcass traits and dressing percentage. The content of selenium in breast and thigh muscle, feathers and excrements increased ($p \leq 0.05$) in both experimental groups compared to the control group. Higher values in breast and thigh muscle and in feathers were measured in the group supplemented with selenium

from Se enriched yeast, also in comparison with the group supplemented with selenium from Se-enriched alga Chlorella. The broiler chickens receiving Chlorella had a higher ($p \leq 0.05$) selenium content in excrements compared to the group with Se enriched yeast. The selenium concentration in liver was higher ($p \leq 0.05$) in both experimental groups compared to the control. The supplement of selenium from Se-yeast and Chlorella in the diet for broiler chickens increased the microelement concentration in muscle.

Mikulski *et al*. (2009) conducted a experiment to verify the assumption that supplementation of the diet for turkeys with selenium, especially in an organic source of Se, improves the antioxidative status of the organism and the stability of the meat. Seven hundred and twenty 1-d-old BUT9 female turkeys were randomly assigned into three experimental groups (8 pens with 30 turkeys in each) and fed a diet without Se supplementation (Se-0) or a diet containing 0.3 mg/kg Se in the form of sodium selenite (SeS) or Se-enriched yeast (SeY). The trial was conducted for 112 days. Dietary supplementation with 0.3 mg/kg Se caused no changes in carcass or muscle yield.

2.7 Effect of Selenium on hematological and immunological parameters

Madron and Vrzgulova (1988) reported that selenium supplementation enhanced the immune system and increased the natural resistant of animals by increasing response of the organism to antigenic stimuli.

Schumacher *et al*. (1987) reported that selenium supplementation stimulates the function of neutrophils, production of antidotes, proliferation of T and B lymphocytes, function of NK cells, etc.

Latshaw (1991) and El-Sebai, (2000) founded that the selenium singly or combining with vitamin-E supplementation to the broiler chickens and Japanese quail diets caused a significant ($p<0.05$) rise in WBC's or RBC's counts.

Hegazy and Adachi (2000), Schrauzer (2000) and Denghua *et al*. (2001) reported an increase in humoral antibody titers when selenium was used in feed, the perceptible reason for enhanced antibody production is increase number of lymphocytes with increased selenium supplementation.

Pavlata *et al*. (2002) noted that another selenium protein is iodothyronine deiodinaze (ID), which regulates the conversion of thyroxin (T4) to the biologically active form of

the hormone of thyroid 3, 3´, 5-tri-iodotyronin (T3). The activation of the thyroid hormone is necessary for the growth of the organism and its adaptability to cold.

Leng *et al*. (2003) compared the influence of either sodium selenite or organic Se sources on the immune system of layer chickens concluded that organic Se supplements improved the status of the avian immune by increasing the ability of immunocompetent cells to respond to an antigen challenge.

Arshad *et al*. (2005) conducted an experiment on 200 chicks. Chicks were raised upto 43 days of age under controlled experimental conditions. The birds were randomly divided into four groups A, B, C and D of 50 birds each at the age of day one. Birds of groups A and B were not supplemented with selenium, while those of groups C and D were given selenium @ 0.06 mg/Kg of feed from day one to day 43. The birds of groups B and D were vaccinated against infectious bursal disease (IBD) at the age of day 10 and boosted at the age of day 25. The effect of selenium on humoral immune response was evaluated by recording weekly serum antibody titres against IBD through indirect haemagglutination (IHA) test. Results indicate that selenium supplementation may help to increase post vaccination humoral immune response against IBD in broiler chicks.

Peng *et al*. (2011) conducted 42-day experiment to investigate the effects of low selenium (Se) on cellular immune function by determining cell cycle of thymus, serum IL-2 content, and mitogenesis of peripheral blood T-lymphocytes. One hundred twenty 1-day-old avian broilers were randomly assigned to two groups of 60 each and were fed on a low-Se diet (0.0342 mg/kg Se) or a control diet (0.2 mg/kg Se), respectively. Cell cycle analysis by flow cytometry showed that low-Se diet caused an increase in G0G1 phase cells that corresponded to a decrease in S-phase cells in thymus. Ultrastructurally, mitochondria injury and increased apoptotic cells with condensed nuclei were observed. Low-Se diet decreased the serum IL-2 contents and mitogenesis of peripheral blood lymphocytes to concanavalin A in comparison with those of control group. These data indicate that low-Se diet inhibits the development of thymus by arresting the cell cycle and decreasing the IL-2 content.

Zhang *et al*. (2012) conducted 75-day experiment to investigate effect of oxidative stress on immunosuppression induced by selenium deficiency by determining immune function in immune organ of chickens. One hundred sixty 1-day-old chickens (egg-type birds) were randomly assigned to two groups of 80 each and were fed on a low-Se diet

(0.032 mg/kg Se) or a control diet (0.282 mg/kg Se, sodium selenite), respectively. Se contents in blood and immune organ (thymus, spleen, bursa of fabricius) were determined on days 30, 45, 60, and 75, respectively. Immune function was examined by determining serum interleukin-1β (IL-1β), interleukin-2 (IL-2), and tumor necrosis factor (TNF) contents. Pathological lesions and DNA damage of immune tissues were observed in low-Se group, while the serum IL-1β and IL-2 contents decreased, and TNF content increased. The present study demonstrated that chickens fed deficient in Se diets exhibited lesions in immune organs, decreased serum IL-1β, IL-2 content, and serum TNF content, indicating that oxidative stress inhibited the development of immune organs and finally impaired the immune function of chickens.

2.8 Effect of Selenium on human health

Rayman and M. P. (2000) conducted large clinical trials to evaluate health effect of selenium on human. He found that selenium, is of fundamental importance to human health. As a constituent of selenoproteins, selenium has structural and enzymic roles, in the latter context being best-known as an antioxidant and catalyst for the production of active thyroid hormone. Selenium is needed for the proper functioning of the immune system, and appears to be a key nutrient in counteracting the development of virulence and inhibiting HIV progression to AIDS. It is required for sperm motility and may reduce the risk of miscarriage. Deficiency has been linked to adverse mood states. Findings have been equivocal in linking selenium to cardiovascular disease risk although other conditions involving oxidative stress and inflammation have shown benefits of a higher selenium status. An elevated selenium intake may be associated with reduced cancer risk.

2.9 Research gap and scope of present investigation

From the above literatures, it is clear that the supplementation of Se to poultry with appropriate doses is always favorable for better growth, reproduction and survivability, and the organic form was found to be superior to inorganic one in most of the cases. The organic form of Se is available in natural feed staffs including the cereal grains like maize, wheat, sorghum etc. However, Se content in feed ingredients depends upon the Se concentration in soil. The selenium concentration in Bangladeshi soil has been reported to be lower (Jason, 2004; Oldfield, 2002) than the standard. So, it is obvious that the feed grains grown on Bangladeshi soil will be deficient of Se. Therefore, there

is a scope of investigating the necessity of Se supplementation in poultry as well as in other animals. But, until recently no work has been done to study the effects of Se supplementation with the appropriate form and levels in poultry rations formulated from locally available ingredients.

CHAPTER-3

MATERIALS AND METHODS

3.1 Statement of the experiment

The research work was conducted at Sher-E-Bangla Agricultural University, Poultry Farm, Dhaka, with 120-day-old chick for a period of 28 days from 11th February to 10th May, 2020 to assess the probability of using Selenium in commercial broiler diet on growth performance, carcass traits and immune parameter of broilers. The experiment was performed by applying different concentration levels of selenium.

3.2 Collection of experimental broilers

A total of 120-day old chicks of "Cobb-500" strain having 44±0.2g average body weight were obtained from Kazi farm limited hatchery, Gazipur, Dhaka.

3.3 Experimental materials

The collected chicks were carried to the university poultry farm. They were kept in electric brooders equally for 7 days by maintaining standard brooding protocol. During brooding time only basal diet was given no selenium was used as treatment. After seven days, 90 chicks were randomly selected from brooders and distributed for dietary treatments of selenium; remaining 30 chicks were distributed randomly in one treatment for control. For proper handling and data collection, the chicks of each treatment group were divided into three replications and in each replication of dietary treatment, there were 10 birds (Table 1). After 28 days of nursing and feeding, data were collected for the following parameters: feed intake, live weight, body weight gain, feed conversion ratio, carcass characteristics, total blood count, profit per bird and benefit-cost ratio.

3.4 Experimental treatments

The selenium was mixed properly with commercial dietary feed at three different level. The experimental treatments were followings:

T_0 = No selenium in basal diets/ control group

T_1 = 0.1g Se/Kg of the feed

T_2 = 0.3g Se/Kg of the feed

T_3 = 0.5g Se/Kg of the feed

Table 1. Lay out of the experiment

Treatment Group	Number of Replication			Total
	R1	R2	R3	
T_0	10	10	10	30
T_1	10	10	10	30
T_2	10	10	10	30
T_3	10	10	10	30
Total	40	40	40	120

3.5 Collection of experimental chemical (Selenium powder)

For the research of effect of different level of selenium supplements on growth performance and immune parameter of Broiler Chicken in Hot-humid climatic condition. Selenium metal power (Qualikems 78.96g) was collected from abroad.

3.5.1 Description about Selenium powder

The selenium powder is Black in color. Its original package was 25kg/bag or 25kg/drum but the collected selenium powder was in white plastic bottle containing 100gm selenium powder.

3.6 Preparation of experimental house

The broiler shed was an open sided natural house. It was a tin shed house with concrete floor. The experimental room was properly cleaned and washed by using tap water. All the equipment of the broiler house was cleaned and disinfected. There was 1ft. side wall around the shed with no ceiling. The floor was above 1ft. from the ground and the top of the roof was above 15ft. from the floor. The house was disinfected by n-alkyl dimethyl benzyl ammonium chloride (TimsenTM) solution before starting the experiment. After proper drying, the house was divided into pens as per lay-out of the experiment by polythene sheet so that air cannot pass one pen to another. The height of pens was 5 ft. Before placement of chicks the house was fumigated by formalin and potassium permanganate @ 500 ml formalin and 250 g potassium permanganate (i.e. 2:1) for 35 m^3 experimental area. Rice husk was used as a litter material to keep free the floor from moisture.

3.7 Experimental diets

Starter and grower commercial Kazi broiler feed were purchased from the market. Starter diet was enriched with minimum:-

Table 2: Experimental diet

Name of Nutrients in Starter diet	Minimum percentage Present (%)
Protein	21.0 %
Fat	6.0%
Fiber	5.0%
Ash	8.0%
Lysine	1.20%
Methionine	0.49%
Cysteine	0.40%
Tryptophan	0.19%
Threonine	0.79%
Arginine	1.26%

Experimental diet (continued)

Name of Nutrients in Grower ration	Minimum percentage Present (%)
Protein	19.0 %
Fat	6.0%
Fiber	5.0%
Ash	8.0%
Lysine	1.10%
Methionine	0.47%
Cysteine	0.39%
Tryptophan	0.18%
Threonine	0.75%
Arginine	1.18%

Feed were supplied 4 times daily by following Cobb 500 Management Manual and *ad libitum* drinking water 2 times daily.

3.8 Management procedures

Different aspects of the management of chicks, experimental events and management procedures are described in detail below:

3.8.1 Litter management

High absorbing bedding material was used as litter on floor. Fresh, clean and sun-dried rice husk was used as shallow litter to absorb moisture from fecal discharge of broiler chicken. The shallow litter was 5 cm (2 inch) in depth. About 250g calcium oxide powder was mixed with rice husk in every pen as disinfectant. At the end of each week the litter was harrowed to prevent accumulation of toxic gases and to reduce moisture and parasitic infection. At 3rd and 4th week of rearing period, droppings were cleaned from the surface level by removing a thin layer of litter and same amount new litter was placed in each pen.

3.8.2 Receiving of day-old chicks

Just after arrival of day-old chicks to the poultry house the initial weight of the chicks were recorded by a digital electronic balance, and distributed them under the hover for brooding. The chicks were supplied glucose water with vitamin-C to drink for the first 3 hours to overcome dehydration and transportation stress. Subsequently small feed particles were supplied on the newspapers to start feeding for the first 24 hours.

3.8.3 Brooding of baby chicks

Electric brooder was used to brood chicks. Due to hot climate brooding temperature was maintained as per requirement. Brooding temperature was adjusted (below 35℃) with house temperature. So, when the environmental temperature was above the recommendation, then no extra heat was provided. At day time only an electric bulb was used to stimulate the chicks to eat and drink. In brooding extra heat was not provided at day time except mid night to morning. Electric fans were used as per necessity to save the birds from the heat stress. Partitioning brooding was done due to different experimental treatment. Each brooder had one hover and a round chick guard to protect chicks and four portioning chambers. Sometimes day temperature was 31-37℃. So, at that time there was no need of extra heat to brood the baby chicks, but at night a 100-watt bulb was used in each pen to rise up low temperature according to heat requirement of brooding schedule. The brooding temperature was checked every 2 hours later by digital thermometer to maintain the temperature of the brooder.

3.8.4 Room temperature and relative humidity

Daily room temperature (℃) and humidity were recorded with a thermometer and a wet and dry bulb thermometer respectively. Daily of room temperature and percent relative humidity for the experimental period were recorded and presented. Average of room temperature and percent relative humidity for the experimental period was recorded and presented in Table 3.

Table 3. Average temperature and humidity

Week	Date	Temperature (℃)		Humidity (%)	
		Average Maximum	Average minimum	Average Maximum	Average minimum
1st	11.02.19- 18.02.19	36.85	26.175	45.375	27
2nd	19.02.19- 25.02.19	31.11	21.36	72.03	42.43
3rd	26.02.19-03.03.19	31.96	20.4	74	42.14
4th	04.03.19-10.03.19	31	20.91	80.43	42

3.8.5 Feeding and drinking

Crumble feed was used as starter (0-2 wks.) and pellet feed for grower (3-4 wks.) ration. *Ad libitum* feeding was allowed for rapid growth of broiler chicks up to the end of the four weeks. Fresh clean drinking water was also supplied *Ad libitum*. Feeds were supplied 3 times: morning, noon and night. Water was supplied two times daily: morning and evening. Left over feeds and water were recorded to calculate actual intake. Digital electronic balance and measuring plastic cylinder was used to take record of feed and water. Daily water consumption (ml) and weekly feed consumption (gm)/bird were calculated to find out weekly and total consumption of feed and water. All feeders and drinkers were washed and sun-dried before starting the trial. One plastic made round feeder and one drinker were kept in the experimental pen. Feeder and drinker size were changed according to the age of the birds. Feeders were washed at the end of the week and drinkers once daily.

3.8.6 Lighting

At night there was provision of light in the broiler house to stimulate feed intake and rapid body growth. A 200watt incandescent bulb lights (1000 lumen) were provided to ensure 24 hours' light for first 2 weeks. Thereafter 23 hours' light and one-hour dark were scheduled up to marketable age. At night one-hour dark was provided in two times by half an hour.

3.8.7 Ventilation

The broiler shed was south facing and open-sided. Due to wire-net cross ventilation was easy to remove polluted gases from the farm. Besides, on the basis of necessity

ventilation was regulated by folding polythene screen. The open space around the farm were favorable for cross ventilation.

3.8.8 Biosecurity measures

Biosecurity is a set of management practices that reduce the potential for introduction and spread of diseases causing organisms. To keep disease away from the broiler, farm the following vaccination, medication and sanitation program was undertaken. All groups of broiler chicks were supplied Vitamin B-Complex, Vitamin-A, D, E, K and Vitamin-C, Ca and Vitamin-D enriched medicine and electrolytes.

3.8.9 Vaccination

The vaccines were collected from medicine shop (Ceva Company) and applied to the experimental birds according to the vaccination schedule. One ampoule vaccine was diluted with distilled water according to the recommendation of the manufacturer. The cool chain of vaccine was maintained strictly up to vaccination. The vaccination schedule of broiler is shown in Table 4.

Table 4. Vaccination schedule

Age	Name of Disease	Name of Vaccine	Route of vaccination
Day 0	Infectious Bronchitis + Newcastle Disease (IB+ND)	CEVAC BI L	One drop in eye
Day 9	Gumboro (IBD)	CEVAC IBDL	Drinking water
Day 17	Gumboro (IBD)	CEVAC IBDL	Drinking water

3.8.10 Medication

Vitamin-B complex, vitamin-A, D3, and E were used against deficiency diseases. Electromin and Vitamin-C also used to save the birds from heat stress. The medication program is presented in the Table 5.

Table 5. Medication programme

Medicine	Composition	Dose	Period
B-Com-Vit	Vitamin B-complex	2-5ml/1L water	3-5 days (all groups)
Renasol AD$_3$E (Vet)	Vitamin A, D & E	1 ml/5L water	3 -5 days (all groups)
Electromin powder	Electrolytes	1g/2L water	4 -5 days (all groups)
Revit-C	Vitamin-C Premix	1g/5L water	4 -5 days (all groups)
Calplex	Ca, P and Vit-D	10 ml/100 bird	3-5 days (all groups)

3.8.11 Sanitation

Proper hygienic measures were maintained throughout the experimental period. Cleaning and washing of broiler shed and its premises were under a routine sanitation work. Flies and insects were controlled by spraying phenol and lysol to the surroundings of the broiler shed. The attendants used farm dress and shoe. There was a provision of wearing polythene shoe at the entry gate of the broiler shed to prevent any probable contamination of diseases. Strict sanitary measures were followed during the experimental period.

3.9 Recorded parameters:

Weekly live weight, weekly feed consumption and death of chicks to calculate mortality percent were taken during the study. FCR was calculated from final live weight and total feed consumption per bird in each replication. After slaughter carcass weight and gizzard, liver, spleen, bursa, intestine and heart were measured from each broiler chicken. Dressing yield was calculated for each replication to find out dressing percentage. Blood sample was collected to observe immune parameter.

3.10 Data collection

3.10.1 Live weight

The initial day-old live weight and weekly live weight of each replication was kept to get final live weight record per bird.

3.10.2 Dressing yield

Dressing yield of bird was obtained from live weight subtracting blood, feathers, head, shank and inedible viscera.

3.10.3 Feed consumption

Daily feed consumption record of each replication was kept to get weekly and total feed consumption record per bird.

3.10.4 Survivability of chicks

Daily death record for each replication was counted up to 28 days of age to calculate mortality if occurred that indicated the survivability of the bird.

3.11. Dressing procedures of broiler chicken

Three birds were picked up at random from each replicate at the 28th day of age and sacrificed to estimate dressing percent of broiler chicken. All birds to be slaughtered were weighed and fasted by halal method or overnight (12 hours) but drinking water was provided *ad-libitum* during fasting to facilitate proper bleeding. All the live birds were weighed again prior to slaughter. Birds were slaughtered by severing jugular vein, carotid artery and the trachea by a single incision with a sharp knife and allowed to complete bleed out at least for 2 minutes. Outer skin was removed by sharp scissor and hand. Then the carcasses were washed manually to remove loose singed feathers and other foreign materials from the surface of the carcass. Afterward the carcasses were

eviscerated and dissected according to the methods by Jones (1982). Heart and liver were removed from the remaining viscera by cutting them loose and then the gall bladder was removed from the liver. Cutting it loose in front of the proventiculus and then cutting with both incoming and outgoing tracts removed the gizzard. Giblet were collected after removing the gall bladder. All the carcasses were washed with cold water inside and out to remove traces blood, loosely attached tissue or any foreign materials. Then the eviscerated weight of carcasses was recorded. Thereafter the weight of carcass cuts such as breast, thigh (both), drumstick (both), back, neck, wing (both), heart, liver and gizzard was taken. Dressing yield was found by subtracting blood, feathers, head, shank, liver, heart and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Percent of breast, thigh, drumstick, back, wing, giblet and abdominal fat were found as DP.

3.12 Immune parameter:

At the end of the experiment blood sample was collected randomly from each replication of every treatments. 2mL blood was collected from wing vein with syringe in a vacutainer. Vacutainer contains EDTA solution which prevent blood coagulants. Few hour after collection the blood sample was tested by Auto Blood Analyzer in SAU Poultry Science Lab.

3.13 Calculations

Each data were collected by the following formulae:

3.13.1 Live weight gain

The average body weight gain of each replication was calculated by deducting initial body weight from the final body weight of the birds.

Body weight gain = Final weight – Initial weight

3.13.2 Feed intake

Feed intake was calculated as the total feed consumption in a replication divided by number of birds in each replication.

$$\text{Feed intake (g/bird)} = \frac{\text{Feed intake in a replication}}{\text{No. of birds in a replication}}$$

3.13.3 Feed conversion ratio (FCR)

Feed conversion ratio (FCR) was calculated as the total feed consumption divided by weight gain in each replication.

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.13.4 Dressing percentage

Dressing yield was found by subtracting blood, feathers, head, shank and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Dressing percentage of bird was calculated by the following formula-

$$DP = \frac{Dressing yield(g)}{Live weight(g)} X100$$

Dressing yield = Breast, thigh, drumstick, back, wing, giblet, abdominal fat weight.

3.14 Statistical analysis

Total data were complied, tabulated and analyzed in accordance with the objectives of the study. Excel Program was practiced for preliminary data calculation. The collected data was subjected to statistical analysis by applying one way ANOVA using Statistical Package for Social Sciences (SPSS version 16.0, 2008). Differences between means were tested using Duncan's multiple comparison test, LSD and significance was set at $P<0.05$.

SOME PICTORIAL VIEW OF RESEARCH EXPERIMENT

Plate 01: Preparation of farm (cleaning and disinfection)

Plate 02: Brooder house preparation and chick receiving

Plate 03: Selenium measurement

Plate 04: Chick observation, preparation of stall and chick distribution

Plate 05: Data collection and supervisor observation

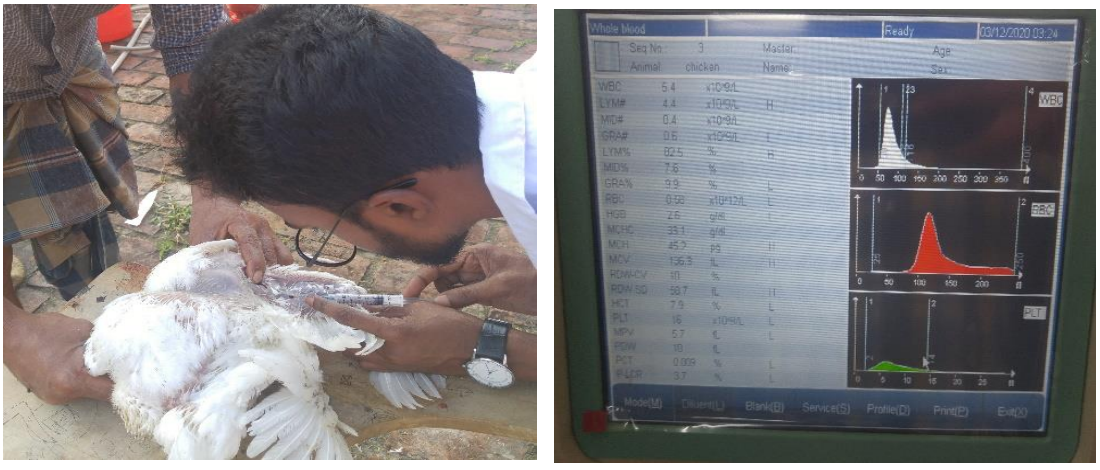

Plate 06: Blood collection and immunity measurement in lab

CHAPTER 4

RESULTS AND DISCUSSION

Production performances of broiler chicken was evaluated by average live weight, average feed Consumption (FC), weekly feed consumption, feed Conversion Ratio (FCR), average body weight gain, weekly body weight gain, survivability and flock uniformity. Carcass characteristics were taken by dressing percentage (DP), carcass weight and relative weight of giblet organs.

The parameters research data analysis is given and discussed below:

4.1 Production performances of broiler chicken

4.1.1 Average live weight

Data presented in Figure 2 and Table 9 showed that the effect of treatments on average live weight (gram per broiler chicken) was significant ($P<0.05$). The relative average live weight (g) of broiler chickens at the end of 4^{th} week in the dietary group T_1, T_2, T_3 and T_0 were 1758.00±9.452, 1799.33±20.537, 1849.33±7.688 and 1827.67±26.245 respectively. The highest live weight was found in T_3 (1849.67±7.83) and lowest result was in T_1 (1758.00±9.45) group.

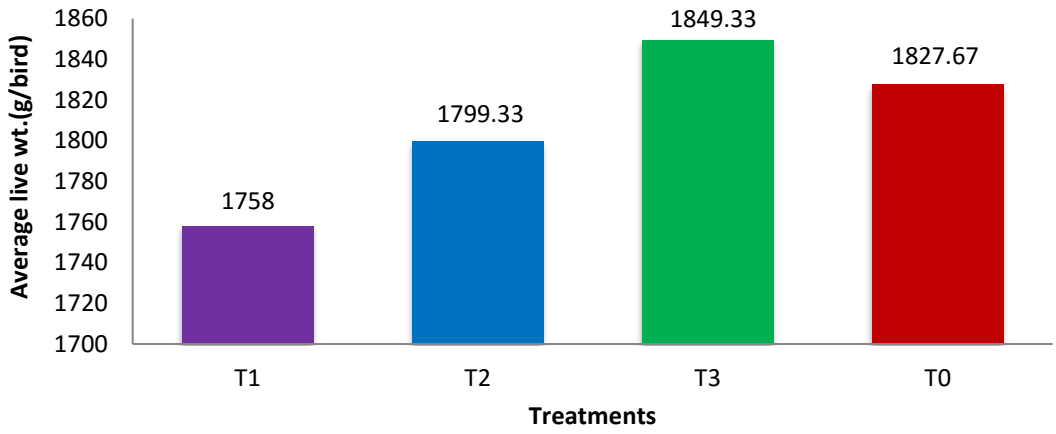

Fig. 2: Average live weight (g/bird)

In Japanese quail kept under a heat stress Sahin and Kucuk (2001) also reported higher performance after the application of a dietary supplement of 250 mg vitamin-E and 0.2 mg Se in the form of Na_2SeO_3. Results were also in accordance with Cantor *et al*. (1982)

who reported higher live weight after dietary Se supplementation in the form of sodium selenite or selenomethionine.

4.1.2 Average feed consumption (FC)

Data presented in Table 9 and Figure 3 showed that the effect of treatments on final feed consumption (gram per broiler chicken) was not significant (P>0.05).

The mean of total feed consumption of broiler chicks at the end of 4th week in the dietary group T_1, T_2, T_3 and T_0 were 2269.83±37.52, 2303.87±36.19, 2314.47±48.29 and 2269.00±45.82 respectively. The highest average feed consumption was found in T_3 (2314.47±48.29) and lowest result was in T_0 (2269.00±45.82) group.

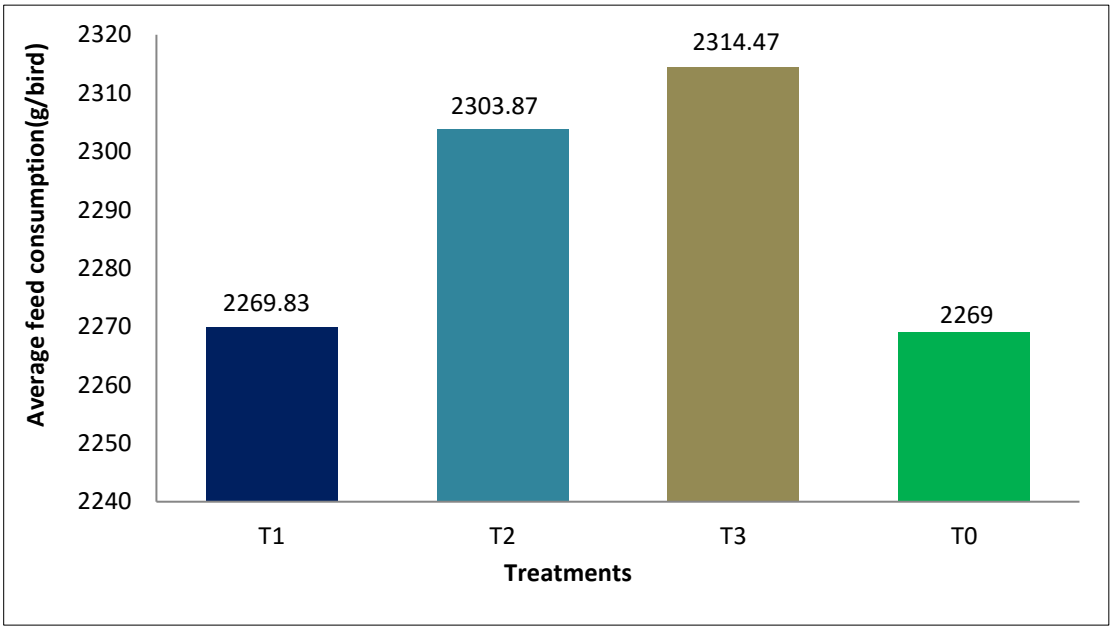

Fig. 3: Average feed consumption (g/bird)

Though the feed consumption increase with the concentration of selenium in feed. Somehow there is no significant (P>0.05). Results of the present study supported the findings of Cantor *et al*. (1982) who reported increased feed intake after dietary Se supplementation in the form of sodium selenite or selenomethionine.

4.1.3 Weekly feed consumption

Data regarding presented in Table 6 showed that the mean feed consumption (g) of broiler chicks at the end of 1st and 2nd week in different groups were no significant (P>0.05) effects.The mean feed consumption (g) of broiler chicks at the end of 3rd and 4th week in different groups was not significant (P>0.05) effects. Somehow feed consumption increased with the selenium supplements.

The mean feed consumption (g) of broiler chicks at the end of 4th week in dietary group T_1, T_2, T_3 and T_0 were 993.03±33.56, 1008.13±43.59, 1029.32±24.36 and 991.83±11.73 gm respectively. The higher feed consumption was in T_3 and comparatively lower in T_0.

Results of the present study supported the findings of Cantor *et al*. (1982) who reported increased feed intake after dietary Se supplementation in the form of sodium selenite or selenomethionine. Results were also in accordance with Sahin and Kucuk (2001) who reported increased feed intake in Japanese quail kept under a heat stress after the application of a dietary supplement of 250 mg vitamin-E and 0.2 mg Se.

Table 6. Effects of Selenium on feed consumption (FC) (g/bird) of broiler chickens at different weeks

Treatment	W1	W2	W3	W4	Total
T_0	185.00±2.63	399.16±5.58	693.00±31.76	991.83±11.73	2269.00±45.82
T_1	187.66±1.44	402.00±10.55	687.13±21.05	993.03±33.56	2269.83±37.52
T_2	185.13±2.71	394.36±1.33	716.76±6.74	1008.13±43.59	2303.87±36.19
T_3	184.93±2.81	392.96±12.61	707.56±17.81	1029.32±24.36	2314.47±48.29
Mean+SE	185.68±1.10	397.12±3.87	701.11±9.74	1005.23±13.83	2289.29±19.03

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method). Mean with different superscripts are no significantly different (P>0.05)

- ✓ SE= Standard Error

4.1.4 Feed conversion ratio (FCR)

Data presented in Table 9 and Figure 4 showed that feed conversion ratio (FCR) was not significant (P>0.05). Feed supplemented with selenium 0.1gm/kg feed at T_1 is better (1.32±0.017).

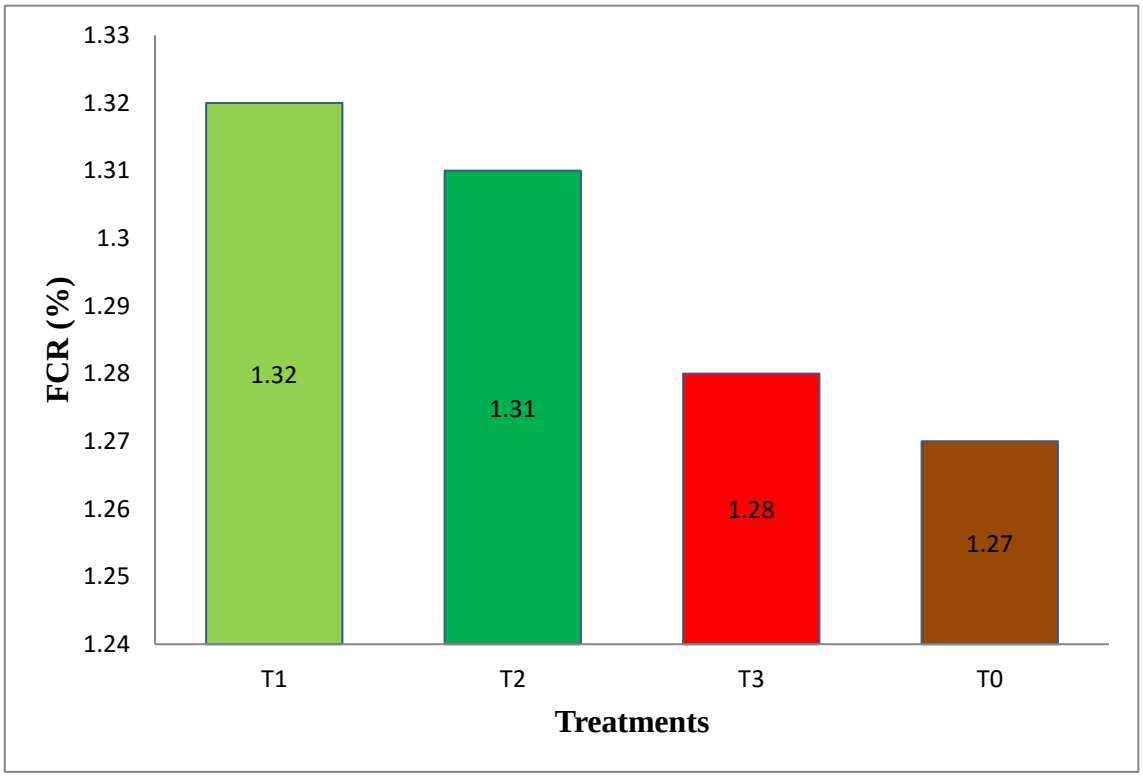

Fig. 4: Feed conversion ratio

However, feed conversion ratio (FCR) was higher in T_1 group (1.32±0.017) and T_2 group (1.31±0.025) compared to T_3 (1.28±0.021) and T_0 (1.27±0.012) groups respectively.

These results are in agreement with the findings of Payne and Southern (2005) who fed supplemental Se source to broiler chicks and observed no differences in feed efficiency.

4.1.5 Average body weight gain

Data presented in Table 9 and Figure 5 showed that the effect of treatments on total body weight gain (gram per broiler chicken) was significant (P<0.05). Somehow there are difference in total body weight gain among treatments. The relative total body weight gain (g) of broiler chickens in the dietary group T_1, T_2, T_3 and T_0 were 1713.75±9.45, 1755.08±20.53, 1805.08±7.68 and 1783.42b±26.24 respectively. The highest result was found in T_3 (1805.08±7.68) and lowest result was in T_1 (1713.75±9.45) group. However among the treatment the more selenium concentration the more body weight gain.

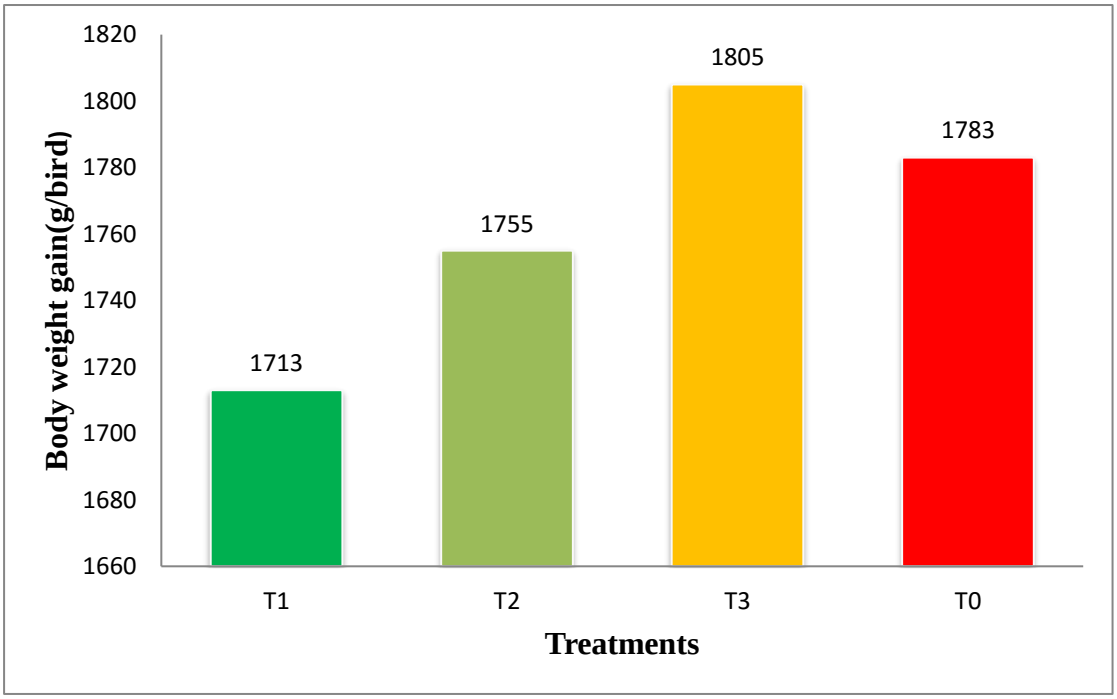

Fig. 5: Average body weight gain (g/bird)

4.1.6 Weekly body weight gain

Data regarding presented in Table 7 showed that the mean body weight gains (g) of broiler chicks at the end of 1st, 2nd , 3rd and 4th week in different groups respectively. The overall mean body weight gains of different groups showed that there was no significant (P>0.05) effects. These results are in agreement with those obtained by Edens *et al*. (2001), and Spears *et al*. (2003) reported no difference in gain or feed intake of broilers fed various concentrations of Se.

Table 7. Effects of Selenium on body weight gain (BWG) (g/bird) of broiler chicken at different weeks

Treatments	Weekly Body Weight Gain				Total BWG
	1ST	**2nd**	**3rd**	**4th**	
T_1	168.42±6.74	356.67±15.98	541.00±21.93	647.67±22.99	1713.75^{b} ±9.45
T_2	162.08±3.66	342.67±6.66	571.67±15.19	678.67±8.95	1755.08^{ab} ±20.53
T_3	167.08±0.88	357.33±5.36	563.00±1.00	717.67±8.41	1805.08^{a} ±7.68
T_0	169.42±1.20	323.67±13.87	594.67±17.85	695.67±30.75	1783.42^{a}±26.24
Mean±SE	166.75±1.87	345.08±6.38	567.58±8.97	684.92±11.54	1764.33±12.78
Signifince	NS	NS	NS	NS	*

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ NS=Non-Significant (P>0.05)
- ✓ * =Significant (P<0.05)

4.1.7 Survivability

The survivability rate showed on Table 9. Survivability rate was statistically higher for the Selenium treated group (100±0.00) than the control group (95.00±5.00) but no significant (P>0.05) difference amongst them. The overall survivability (0-4 weeks) during the experimental period was higher in the treatment group. The variation in mortality among the control group might be due to the seasonal influence of summer season. The possible cause of survivability might be due to the development of immunity amongst the treatment group than control. These results are in agreement with Wang and Zhou (2011) who conducted an experiment to investigate the effect of feed supplementation with nano elemental Se (Nano-Se) on growth performance, tissue Se distribution, meat quality, and glutathione peroxidase (GSH-Px) activity in Guangxi Yellow chicken. They found selenium improve survivability.

4.1.8 Flock uniformity

Data presented in Table 8 showed that the flock uniformity of broilers fed diet containing Selenium antibiotic and control group showed a non-significant (P>0.05) difference among the groups. The flock uniformity is better in Treatment T_1 (74.40±7.80) and comparatively lower in T_3 (65.00±5.00). Other treatment group is more or less similar.

Table 8. Effects of Selenium on uniformity of broiler chicken

Treatment	Uniformity (%)
T_0	72.56±6.31
T_1	74.40±7.80
T_2	72.20±4.02
T_3	65.00±5.00
Mean+SE	71.59±2.80
Significance	NS

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ SE= Standard Error
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ NS=Non-Significant (P>0.05)

Table 9. Effects of Selenium on production performances of broiler chicken

Treatments	Average Live Weight (g/bird)	Average BWG (g/bird)	Average FC (g/bird)	Final FCR	Survivability
T_0	1827.67^{a}±26.245	1783.42^{a}±26.24	2269.00±45.82	1.27±0.012	95.00±5.00
T_1	1758.00^{b}±9.452	1713.75^{b}±9.45	2269.83±37.52	1.32±0.017	100.00±0.00
T_2	1799.33^{ab}±20.537	1755.08^{ab}±20.53	2303.87±36.19	1.31±0.025	100.00±0.00
T_3	1849.33^{a}±7.688	1805.08^{a}±7.68	2314.47±48.29	1.28±0.021	100.00±0.00
Mean±SE	1808.58±12.780	1764.33±12.78	2289.29±19.03	1.29±0.010	99.09±0.90
Significance	*	*	NS	NS	NS

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ SE= Standard Error
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ NS=Non-Significant (P>0.05)
- ✓ * =Significant (P<0.05)

4.2 Carcass characteristics

4.2.1 Dressing percentage (DP)

Data presented in Table 10 showed that the dressing percentage at T_2 (66.8067±0.36) group was significant (P<0.05) carcass percentage compared with the other treatment group T_1 (66.0400±0.54), T_3 (65.4733±0.35) and T_0 (63.8567±0.18). Experiment, evaluation of dressing percentage on slaughtered representative birds revealed that T_2 group had significantly higher dressed percentage followed by T_1, T_3 and lower in T_0 groups.

These results are in agreement with Sahin and Kucuk (2001) who reported higher dressing percentage after the application of a dietary supplement of 250 mg vitamin-E and 0.2 mg Se in the form of Na_2SeO_3 under heat stress on quail. Results were also in accordance with Cantor *et al*. (1982) who reported higher carcass weight after dietary Se supplementation in the form of sodium selenite or selenomethionine.

Table 10. Effects of Selenium on dressing percentage of broiler chicken

Treatment	Live Weight	Eviscerated Weight	Dressing %
T_0	2082.67^{a}±143.15	1330.33^{ab} ±93.70	63.8567^{c}±0.18
T_1	1756.67^{b}±28.41	1160.33^{b}±24.59	66.0400^{ab}±0.54
T_2	1904.00^{ab}±57.14	1286.33^{ab}±57.35	66.8067^{a}±0.36
T_3	2139.00^{a}±33.50	1400.67^{a}±19.09	65.4733^{b}±0.35
Mean+SE	1970.58±56.90	1294.42±35.89	65.5442±0.36
Significance	*	*	*

Here, T_1 = (Selenium0.1g/kg feed), T_2 = (0.3g/kg feed), T_3 = (0.5g/kg feed) and T_0 = (control) Values are Mean ± S.E (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ * =Significant (P<0.05)

4.2.2 Carcass weight

Data presented in Table 11 showed that the carcass weight in the treatment groups are better than the control group. The results revealed that the treatments had significant effects ($P<0.05$) in dressed wings, breast, back, thigh, drumstick, neck. However in treatment T_2 group the carcass weight is better than on other treatment groups.

The present findings were in agreement with previous findings (Choct *et al*. (2004) who reported that higher carcass and breast meat yield in broilers' carcass that received selenium enriched yeast in feed.

Table no 11. Effects of Selenium on carcass characteristics of broiler chickens

Treatment	Breast (g/bird)	Back (g/bird)	Thigh (g/bird)	Drumstick (g/bird)	Wings (g/bird)	Neck (g/bird)
T_1	517.67^{a}±6.19	222.33^{a}±2.33	154.33^{b}±1.45	196.33^{ab}±3.17	85.00^{a}± o.57	44.33^{a}±0.33
T_2	526.33^{a}±11.66	233.00^{a}±1.52	170.00^{a}±1.15	202.00^{a}±2.00	79.00^{b}±1.52	43.67^{a}±1.20
T_3	490.33^{ab}±14.81	168.33^{b}±5.84	169.00^{a}±2.08	191.00^{b}±2.64	75.33^{b}±1.45	43.00^{a}±0.57
T_0	451.00^{b}±16.62	150.33^{c}±2.18	144.00^{c}±1.52	163.67^{c}±3.18	67.00^{c}±1.15	39.33^{b}±0.82
Mean±SE	496.33±10.41	193.50±10.64	159.33±3.32	188.25±4.62	76.58±2.03	42.58±0.67
Significance	*	*	*	*	*	*

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different ($P<0.05$)
- ✓ SE= Standard Error
- ✓ Mean within same superscripts don't differ ($P>0.05$) significantly
- ✓ * =Significant ($P<0.05$)

4.2.3 Relative weight of giblet organs

Data presented in Table 12 showed that relative weight of giblet organs (liver, gizzard and proventriculus) of broilers fed diet containing Selenium metal powder and control group showed significant difference ($P<0.05$) among the groups. In Selenium treatment group the weight of giblet organ is higher than in control group. This is due to positive effect of selenium on carcass trait of chicken.

The present findings were in agreement with previous findings (Choct *et al*., 2004) who reported that higher carcass and breast meat yield in broilers' carcass that received selenium enriched yeast in feed.

Table 12: Effects of Selenium on internal organs of broiler chicken under different treatment group

Treatments	Liver (g/bird)	Heart (g/bird)	Gizzard (g/bird)	Proventriculus (g/bird)	Spleen (g/bird)
T_1	53.00^{a}±.577	13.33±0.333	29.33^{a}±1.856	10.33^{b}±0.333	2.67±0.333
T_2	55.67^{a}±1.453	13.33±0.333	20.33^{b}±0.333	12.33^{a}±0.333	2.67±0.333
T_3	45.67^{b}±.333	12.33±0.333	20.67^{b}±0.333	10.67^{b}±0.333	2.33±0333
T_0	39.00^{c}±.577	12.67±0.333	21.67^{b}±0.333	11.33^{ab}±0.333	2.33±0.333
Mean±SE	48.33±1.997	12.92±0.193	23.00±1.187	11.17±0.271	2.48±.273
Significance	*	NS	*	*	NS

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different (P<0.05)
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- ✓ NS=Non-Significant (P>0.05)
- ✓ * =Significant (P<0.05)

4.3 Immune parameters:

The immune parameter mainly WBC, Lymphocyte and Granulocyte was counted and the data has presented in Table 13 and Figure 12. The WBC, Lymphocyte and Granulocyte was statistically insignificant (P>0.05) among different treatment. The highest WBC (57.76±3.05) and Lymphocyte (52.03±3.14) found in T_3. Highest granulocyte was in control (4.43±0.80) which indicate low immunity in control group. The lowest WBC (38.50±16.58), Lymphocyte (34.60±15.13) and Granulocyte (2.60±1.00) found in T_2.

These results are contradictory with the findings of Latshaw (1991), El-Sebai, (2000) who founded that the selenium singly or combining with vitamin-E supplementation to the broiler chickens and Japanese quail diets caused a significant ($p<0.05$) rise in WBC's or RBC's counts. And with Hegazy and Adachi (2000), Schrauzer (2000) and Denghua *et al*. (2001) who reported an increase in humoral antibody titers when selenium was used in feed, the perceptible reason for enhanced antibody production is increase number of lymphocytes with increased selenium supplementation.

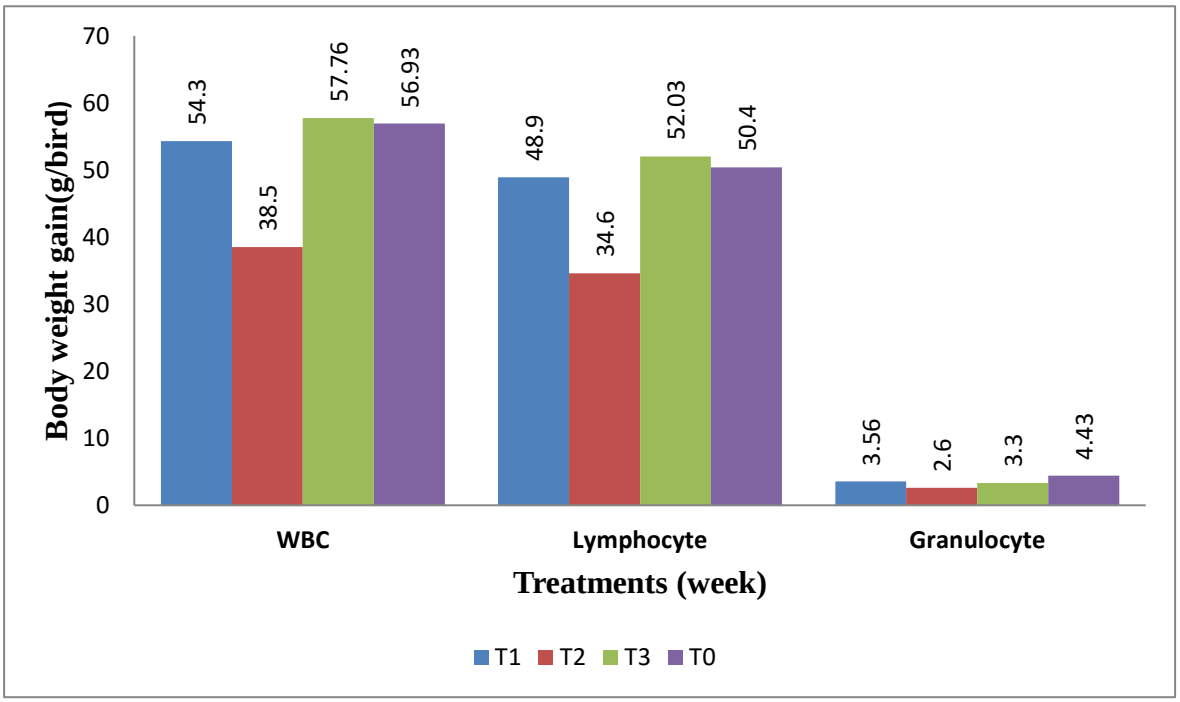

Fig. 12: Effects of Selenium on immune parameters of broiler chicken under different treatment groups

Table 13: Effects of Selenium on immune parameters of broiler chicken under different treatment groups

Treatment	WBC ($x10^9$)	Lymphocyte ($x10^9$)	Granulocyte ($x10^9$)
T_0	56.93±3.27	50.40±4.03	4.43±0.80
T_1	54.30±3.33	48.90±2.98	3.56±0.56
T_2	38.50±16.58	34.60±15.13	2.60±1.00
T_3	57.76±3.05	52.03±3.14	3.30±0.34
Mean+SE	51.87±4.41	46.48±4.05	3.47±0.36
Significance	NS	NS	NS

Here, T_1 = (Selenium 0.1g/kg feed), T_2 = (Selenium 0.3g/kg feed), T_3 = (Selenium 0.5g/kg feed) and T_0 = (control) Values are Mean ± SE (n=12) one way ANOVA (SPSS, Duncan method).

- ✓ Mean with different superscripts are significantly different ($P<0.05$)
- ✓ SE= Standard Error
- ✓ Mean within same superscripts don't differ ($P>0.05$) significantly
- ✓ NS=Non-Significant ($P>0.05$)

CHAPTER 5

SUMMARY AND CONCLUSION

The present study was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka Poultry Farm for a period of four weeks using Selenium commercially available as "Selenium Metal Powder". The experiment was performed by applying different concentration levels of Selenium with commercial broiler feed. The specific objectives of this study was undertaken to determine the efficacy of Selenium i) to evaluate the production performance of broiler, ii) to determine the carcass quality of broiler, iii) to estimate the immune parameters of broiler in hot humid climatic condition A total of 120 day-old Cobb-500 broiler chicks were purchased from Kazi hatchery, Gazipur, Dhaka. The experimental broilers were allocated randomly to 3 treatments and a control group with three replications having 10 broilers per replication. The experiment lasted for 4 weeks and the treatment of various groups consisted of group T_0= No Se supplement i.e. Control group, T_1= 0.1gm Se per 1 kilogram of feed, group T_2= 0.3gm Se per 1 kilogram of feed and group T_3= 0.5gm Se per 1 kilogram of feed. The performance traits viz. body weight, weight gain, feed consumption, FCR, dressed bird weight, relative giblet weight, survivability, flock uniformity, meat yield and immune parameters of broiler on different replication of the treatments was recorded and compared in each group. At 28 days of age, broilers were dissected to compare meat yield characteristics among different treatments.

Final live weight was significantly higher in group T_3 (1849.33±7.688) compared to any other group T_0, group T_2 and group T_1 (1758.00a±9.452) was comparatively lower. However better value was found in group T_3. Body weight gain was also significantly higher in group T_3 (1805.08±7.68) compared to group T_1, group T_2 and group T_0. The lowest value was found in T_1 (1713.75±9.45). FCR was insignificant ($P>0.05$) among treatment group. Somehow treatment group show higher FCR than control. There was no significant ($P>0.05$) difference in weekly feed consumption. Though total feed consumption was higher in treatment group than control group. Which indicates selenium increase feed intake.

There were no significant ($P>0.05$) difference in survivability. No bird was died in treatment group which show higher survivability in treatment than control. The

uniformity was more or less good in all treatment groups. In T_1 it is (74.40±7.80) higher than another. In experiment, evaluation of dressing percentage on slaughtered representative birds revealed that T_2 (66.8067±0.36) group had significantly higher dressing percentage followed by T1, T3 and lower in T_0 groups (63.8567a±0.18). In Selenium treatment group the weight of carcass parts are higher than in antibiotic and control group. The results revealed that the treatments had significant effects in dressed brest, back, thigh, drumstick, wings and neck ($P<0.05$). But in T_2 treatment group the carcass weight is better than any other treatment group. The results revealed that the treatments had significant effects in giblet organ liver, gizzard and proventriculus ($P<0.05$), but no significant difference in heart and spleen ($P>0.05$). The overall mean weekly body weight gains of different groups at 4th week showed that there was no significant ($P>0.05$) effects. There was no significant ($P>0.05$) difference in weekly feed consumption among the Se treated groups. There is no significant ($P>0.05$) difference in immune parameter (WBC, Lymphocyte and Granulocyte). Somehow T_2 was comparatively better.

The results of the current study indicate that Se increase feed intake, FCR, Survivability and dressing percentage but no impact on body weight gain, live weight and immunity.

Analyzing the above research findings on the growth performance of broilers, the Selenium had no effect on growth performance of broiler. It can be recommended by the study that the Selenium don't hamper growth of broiler therefore it can be use with feed for human health benefit. Because the residual Selenium has a positive impact on human health and Selenium is an essential micronutrient for human. Therefore it is strongly suggest that Selenium can be used in our country for quality poultry meat for healthier life with safe food consumption. However commercial application is recommended.

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APPENDICES

Appendix 1. Effects of Selenium on production performances of broiler chicken

Treatment	Replication	Final Live Weight (G/Bird)	Total Feed Consumption (G/Bird)	Total Body Weight Gain (G/Bird)	Final FCR	Survivability
T_1	R_1	1740	2239.9	1695.75	1.32	100
	R_2	1762	2225.2	1717.75	1.29	100
	R_3	1772	2344.4	1727.75	1.35	100
T_2	R_1	1774	2245.6	1729.75	1.29	100
	R_2	1784	2370.2	1739.75	1.36	100
	R_3	1840	2295.8	1795.75	1.27	100
T_3	R_1	1834	2220.3	1789.75	1.24	100
	R_2	1858	2380.2	1813.75	1.31	100
	R_3	1856	2342.9	1811.75	1.29	100
T_0	R_1	1805	2195.1	1760.75	1.24	90
	R_2	1798	2259	1753.75	1.28	100
	R_3	1880	2352.9	1835.75	1.28	90

Appendix 2: Recorded temperature and relative humidity% during experimental period

Age in weeks	Period	Average Temperature ^{0}C	Average Humidity %
1st	11.02.20-18.02.20	31.5	40.0
2nd	19.02.20-25.02.20	27	54.5
3rd	26.02.20-03. 03.20	29.6	58.0
4th	04.03.20-10.03.20	26.9	63.87

Appendix 3. Effects of Selenium on dressing percentage of broiler chicken (g/bird)

Treatment	Replication	Average Live Weight	Eviscerated Weight	Dressing %
T_1	R_1	1705	1126	66.04
	R_2	1762	1147	65.09
	R_3	1803	1208	66.99
T_2	R_1	2080	1401	67.35
	R_2	1854	1226	66.12
	R_3	1840	1232	66.95
T_3	R_1	2196	1438	65.48
	R_2	2141	1389	64.87
	R_3	2080	1375	66.10
T_0	R_1	2290	1462	63.84
	R_2	2150	1380	64.18
	R_3	1808	1149	63.55

Appendix 4. Effects of Selenium on carcass characteristics of broiler chickens (g/bird)

Treatment	Replication	Breast	Back	Thigh	Drumstick	Wing	Neck
T_1	R_1	508.0	218.0	152.0	189.0	84	44
	R_2	516.0	223.0	154.0	199.0	85	45
	R_3	529.0	226.0	157.0	201.0	86	44
	R_1	523.0	232.9	170.2	204.5	80	43
T_2	R_2	548.0	236.0	172.5	204.5	81	46
	R_3	508.0	231.7	168.5	198.4	76	42
	R_1	512.0	180.0	170.5	196.4	75	43
T_3	R_2	462.0	163.0	165.0	187.0	73	42
	R_3	497.0	162.0	172.0	190.3	78	44
	R_1	423.4	146.8	141.0	158.6	67	39
T_0	R_2	450.7	152.0	145.0	164.0	69	38
	R_3	480.6	153.0	146.0	169.3	65	41

Appendix 5. Effects of Selenium on internal organs of broiler chicken under different treatment groups (g/bird)

Treatment	Replication	Liver	Heart	Gizzard	Proventriculus	Spleen
T_1	R_1	52	13	27.0	11.0	2.00
	R_2	54	14.0	33.0	10.0	2.56
	R_3	53	13	28.5	10.0	2.51
T_2	R_1	56	12.8	21.5	11.8	2.40
	R_2	58	13.0	20.5	13.5	2.42
	R_3	57	13.0	20.0	12.2	2.36
T_3	R_1	46	12.0	20.0	11.5	1.82
	R_2	45	12.0	20.0	10.0	1.75
	R_3	46	12.6	21.4	11.0	1.85
T_0	R_1	39	13.0	22.0	11.5	1.92
	R_2	40	13.0	22.0	11.0	1.88
	R_3	38	12.0	21.0	11.0	1.89

Appendix 6. Effects of Selenium on uniformity of broiler chicken

Treatment	Replication	Uniformity (%)	Average uniformity (%)
T_1	R_1	90.0	74.40±7.80
	R_2	66.6	
	R_3	66.6	
T_2	R_1	80.0	72.20±4.02
	R_2	66.6	
	R_3	70.0	
T_3	R_1	70.0	65.00±5.00
	R_2	60.0	
	R_3	66.6	
T_0	R_1	77.7	72.56±6.31
	R_2	60.0	
	R_3	80.0	

Appendix 7. Effects of Selenium on body weight gain (BWG) (g/bird) of broiler chicken at different weeks (g/bird)

Treatment	Replication	1st week BWG	2nd week BWG	3rd week BWG	4th week BWG	Total BWG
T_1	R_1	178.75	353	507	657	1695.75
	R_2	170.75	331	534	682	1717.75
	R_3	155.75	386	582	604	1727.75
T_2	R_1	165.75	336	567	661	1729.75
	R_2	165.75	336	548	690	1739.75
	R_3	154.75	356	600	685	1795.75
T_3	R_1	168.75	353	564	704	1789.75
	R_2	165.75	368	564	716	1813.75
	R_3	166.75	351	561	733	1811.75
T_0	R_1	171.75	299	629	661	1760.75
	R_2	168.75	347	569	669	1753.75
	R_3	167.75	325	586	757	1835.75

Appendix 8 Effects of Selenium on feed consumption (FC) (g/bird) of broiler chickens at different weeks (g/bird)

Treatment	Replication	1st week FC	2nd week FC	3rd week FC	4th week FC	Total FC
	R_1	190.2	395.7	723.1	930.9	2239.9
T_1	R_2	185.2	387.7	650.2	1002.1	2225.2
	R_3	187.6	422.6	688.1	1046.1	2344.4
	R_1	180.9	395.7	727.1	941.9	2245.6
T_2	R_2	184.3	391.7	704.1	1090.1	2370.2
	R_3	190.2	395.7	719.1	990.8	2295.8
	R_1	181.3	391.7	632.3	989.8	2195.1
T_3	R_2	183.6	395.7	707.1	972.6	2259
	R_3	190.1	410.1	739.6	1013.1	2352.9
	R_1	184.58	412.75	733.75	853.75	2184.83
T_0	R_2	183.58	401.88	757.13	927.88	2270.47
	R_3	178.50	407.50	735.00	906.25	2227.25